

FIELD TECHNIQUES FOR FOREST AND RANGE ROAD REMOVAL



**California State Parks
North Coast Redwoods District
Roads, Trails, and Resources**

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**California State Parks
North Coast Redwoods District
Roads, Trails, and Resources Maintenance**

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TABLE OF CONTENTS

ACKNOWLEDGEMENTS	iv
INTRODUCTION	1
PURPOSE	1
SCOPE	1
AUDIENCE	2
WHY ROAD REMOVAL?	2
EROSION – FRIEND AND FOE!	2
HOW A ROAD BECOMES A RIVER	4
IMPACTS FROM RILLS GULLIES, AND LANDSLIDES	5
PERSONNEL AND EQUIPMENT	7
ROLE OF THE INSPECTOR	7
ROLE OF THE EQUIPMENT OPERATOR	9
SELECTING THE RIGHT EQUIPMENT FOR THE EXCAVATION	11
SITE PREPARATION	12
DEVELOPING ACCESS	12
BRUSHING	13
PREPARING THE ROAD SURFACE	14
ROAD REMOVAL TREATMENTS	16
FULL RECONTOURING	16
MATCHING THE CUTBANK	19
THROUGH-CUT RECONTOURING	19
TERRAFORMING	21
ROAD DECOMMISSIONING	23
FINISH GRADING	27
MULCHING	27
ROAD-TO-TRAIL CONVERSION	28
THE CONVERSION PROCESS	30
SHAPING AND MULCHING THE TRAIL	32
STREAM CROSSINGS ON ROAD-TO-TRAIL CONVERSIONS	32
ROAD STREAM CROSSING REMOVAL	33
MATCHING THE GRADE	34
FINISH GRADING AND MULCHING	37
SPRINGS AND SEEPS	38
PROTECTING THE LANDSCAPE	39
SAFETY ON THE JOBSITE	41
ADAPTIVE MANAGEMENT	44

WATERSHED COLLABORATION	44
APPENDIX A	A-1
TYPICAL DIAGRAMS FOR ROAD AND STREAM CROSSING REMOVAL	A-1
APPENDIX B	B-1
GLOSSARY	B-1
APPENDIX C	C-1
LITERATURE AND OTHER RESOURCES	C-1
LITERATURE	C-2
INTERNET RESOURCES	C-2

GEOLOGIC AND ENGINEERING SERVICES

Laws and regulations governing geologic and engineering services may apply to certain construction activities where public and private property issues, environmental and safety concerns, or engineered structures are encountered. Be sure and consult local, State, and Federal regulations to determine if your activities require review and approval of a licensed geologist and/or engineer. If review and approval are required, you must employ a professional who is licensed to practice in the state in which the work is to take place.



Working together is the key to success. The excavator feeds crossing fill to the dozer for spreading and compaction.

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INTRODUCTION

PURPOSE

This guide was developed as a primer for watershed and construction professionals of all experience levels. It focuses on field construction techniques related to road removal or conversion to trail. Because most watershed/road publications available today focus on road related impacts and watershed assessment, we targeted this guide toward actual construction techniques and construction planning. It provides specific information on construction techniques to contractors, regulatory agencies, heavy equipment operators, and watershed workers, it can also be used as a public information “brochure” to outline rehabilitation work that may be planned in sensitive areas or public lands.

If you are reading this guide, chances are you are involved with or interested in some type of watershed rehabilitation. What exactly is watershed rehabilitation? Loosely defined, it is a process where disturbances to the slopes, streams, soils, and vegetation are evaluated and treated to allow natural processes to recover, over time, to a predisturbance condition. Disturbances can include, fire, logging, road construction, and other natural or man-made occurrences. In this guide, we will be focusing on the effect and treatment of roads on the natural landscape.

SCOPE

The techniques described in this guide were developed and tested in coastal northern California. They are not intended to be used as universal techniques for planning and implementing road removal projects. The topography, geology, climate, and vegetation of coastal northern California were all factored into the development of these techniques. However, treatment objectives can in most cases be met by modification of these techniques to accommodate local conditions.

The road removal techniques described in this guide fall into three general categories: full recontouring, decommissioning, and road-to-trail conversion. Typically, full recontouring is prescribed for roads that will not be used again. Decommissioning is prescribed to stabilize roads that may be used again after a period of time. Road-to-trail conversions are used to convert suitable roads into recreational trails. Depending on your objectives, one or more of these treatment options can be used to eliminate a problem road.



Road removal employs heavy equipment to treat problem roads and stream crossings. Left, an excavator and dozer work together to remove road fill from a stream crossing. Right, the excavator recovers fill and feeds it to the dozer. The dozer then pushes the material to a stable location, shapes it, and compacts it.

AUDIENCE

This guide has been written in non-scientific terms and is intended for persons conducting field operations related to road removal. This may include: contractors, equipment operators, watershed planners, field technicians, land owners, etc. This guide does not intend to, nor is it capable of, supplanting trained, experienced, and skilled watershed scientists and workers. It is intended to supplement their knowledge and provide guidelines for them to operate under. It can also provide a basic knowledge of road removal planning and implementation techniques for inexperienced persons. Scientific treatments of watershed principles can be found in numerous publications and reports. We have listed selected publications in Appendix 3.



Watershed rehabilitation projects in Redwood National and State Parks continue to remove thousands of cubic yards of unstable road fill. Left, a large haul road used for heavy truck traffic. Right, a recontoured slope following road removal.

WHY ROAD REMOVAL?

EROSION – FRIEND AND FOE!



Gullies and rills, caused by concentrated water on the road, contribute large volumes of sediment to streams over time. This road has become impassable due to gullies formed by water concentrating and flowing down the road.

The landscape we observe today has been shaped over millions of years. Mountains rise as the earth's crust is deformed. At the same time, and at about the same rate, erosion wears them down. Erosion results from many things: wind blowing across desert sand, waves crashing onto a beach, and glaciers grinding away at mountain tops. For watershed professionals, runoff from rainfall and snowmelt is our number one concern. In an undisturbed landscape, erosion is kept in check by vegetation and slope among other things. These features



Road related erosion is often caused by diversion of natural flow paths onto a road. Concentrated flow from a failed stream crossing cuts a gully as it washes over the erodible embankment.



Runoff flows through a recently excavated stream crossing. Because all of the potentially unstable fill has been moved to a stable location, the erosion threat has been greatly reduced.

moderate runoff and keep excessive erosion from occurring. Disturbances such as road building disrupt the delicate balance between runoff and the landscape and lead to accelerated soil erosion and watershed degradation.

Erosion is not necessarily a bad thing. It is a natural and necessary process. Over millions of years streams erode valleys and move sediment toward the ocean. The process of natural erosion is very slow and occurs

over a long period of time. When a stream is in long-term balance with its sediment supply, geologists refer to it as a graded stream.

Species dependent on streams for habitat, such as salmon, have adapted to the graded condition. Sediment in the stream provides spawning and rearing habitat. When the stream suddenly and dramatically scours or fills due to a change in the sediment supply, many species must struggle to survive.



Reconouring the slope to eliminate road related drainage problems can greatly reduce road related erosion such as gullying and landsliding.



A diverted stream flows down a road and away from the natural drainage. Active stream diversions are a major cause of watershed degradation. Thorough watershed assessment and rehabilitation can eliminate most of these problems.

slope, rock armor and vegetation so they are highly erosive leading to severe sedimentation problems in natural streams below.

Road stream crossings with or without culverts may plug and divert water onto road surfaces. Inboard ditches intercept and collect water from the slopes above and water collects on the road, directly flowing along tire ruts and the road surface. In many instances, diverted water flows off the road along slopes where no stream channel exists. Diverted runoff flowing onto slopes can result in large landslides and severe gullying.

As long as diversions remain, erosion will continue. If left uncorrected, natural flow patterns can become permanently diverted and contribute large volumes of sediment to the stream channels. If roads are constructed with

HOW A ROAD BECOMES A RIVER

In the late fall, as the first storms begin to bring rain to our region, rainfall is soaked up by trees, brush, organic matter, and soil. Streams remain low and slow as they do in the summer months. As storms continue into the winter and more rain falls, the vegetation and soil eventually become saturated. Once saturated the landscape cannot absorb more water and runoff begins to flow across the surface of the ground collecting in small depressions. Small depressions collect water and join to form small streams. Small streams join to form larger and larger streams as runoff moves through the watershed, eventually draining into a lake or the ocean. In undisturbed landscapes stream channel erosion is kept in check by complex interactions between water flow, streambed roughness and the gradient of the channel. Vegetation, logs, and rock combine to armor stream banks and protect the streambed from the force of erosion.

As roads are added to a watershed, the potential for runoff diversion by roads increases. Once diversions begin, the roads often become permanently connected to the drainage network. Unlike natural streams, roads do not have the right combination of



Where water concentrates in unnatural locations, it can cause rills, gullies, and landslides. This 15 foot gully is the result of water diverted out of its natural channel and down an abandoned road. The gully traversed 2 miles across a slope before causing a large landslide.



Prairie soils are very erosive due to high water tables and low root strength. Large gullies often develop where concentrated water drains off a road onto unstable slopes. Left, looking down a large gully cut into an upland prairie caused by diverted runoff. Right, water collected in an inboard ditch drains from a culvert cross drain into a large gully and landslide below.

an inboard ditch or have an outside berm, overland flow can become concentrated and form a rivulet or small stream. As more and more water collects and concentrates, the erosional force can quickly increase resulting in very large gullies and landslides.

IMPACTS FROM RILLS GULLIES, AND LANDSLIDES

Rills and gullies are very common problems on roads. They form where water concentrates on the road and causes soil erosion. Rills are smaller than one (1) square foot and gullies are larger than one (1) square foot in cross-section area. Rills and gullies often form along the path of abandoned roads where water is confined in tire ruts or by a berm. Gullies can enlarge to more than 20 feet deep and 50 feet wide in some cases and extend for thousands of feet down a road.



A large landslide related to the concentration of water in an inboard ditch. The landslide dumped an estimated thirty-thousand cubic yards of sediment directly into the creek, plugging the stream temporarily. This landslide continues to spread upward as the slope adjusts to a new equilibrium. Notice the pickup truck parked on the road in upper right corner of the photo for scale.

Mass movements, also called mass wasting, includes landslides, embankment failures, and any other massive movement of soil and rock. Mass movements can be triggered by earthquakes, heavy rainfall, stream diversions, and concentrated flow on roads. Mass movements may contribute a large amount of sediment into a stream system all at once, creating a slug of sediment that causes severe disruption to the stream habitat. Sediment slugs move through the stream slowly, prolonging impacts for many years after a landslide.

The goal of rehabilitation is to restore natural runoff patterns to a predisturbance condition. This includes removal of stream crossings that can divert runoff onto roads,



Cutbank failures are common in steep loose soils and along inner gorge sections of the slope. The oversteepened slope caused by the cutbank results in instability. Road recontouring helps reduce the likelihood of cutbank failures by reducing slope and butressing unstable material above.

elimination of confined flow along roads and inboard ditches, and elimination of flow onto unstable slopes that often results in chronic mass wasting.

Road removal is just one aspect of watershed rehabilitation. A comprehensive watershed rehabilitation program should also include stream channel rehabilitation, upland and riparian revegetation, road re-engineering, and a well-designed monitoring component. Watershed rehabilitation is a rapidly evolving science so adaptive management and technology sharing also play key roles in a watershed rehabilitation program.



Undersized culverts can easily plug with sediment or woody material, causing major erosion problems on forest roads. This culvert failure deposited 40 cubic yards of material directly into a stream.



Stream diversions caused by a plugged or undersized culvert can lead to severe gullying. The diversion causing this gully was eliminated by removing the crossing fill and adjacent road approaches.



The inspector is responsible for directing day-to-day operations and assisting the operator in understanding the treatment prescriptions and contract specifications. Left, a State Parks geologist helps the excavator operator locate a buried culvert. Right, the inspector guides equipment to the next work site.

PERSONNEL AND EQUIPMENT

ROLE OF THE INSPECTOR

Road removal projects are planned over many months by a team of watershed professionals, including geologists, biologists, ecologists, and heavy equipment operators. Typically, a geologist trained in stream and slope processes assumes the responsibility for coordinating road removal projects. Acting as team leader, the geologist carries out the field investigations and informs the team about the conditions of a watershed. The geologist develops maps of the drainage patterns, road network, stream diversions, landslides, and gullies. Using the maps and field observations made by the geologist, the team analyzes the information to determine exactly what sites need work. Individual road segments are carefully analyzed to determine the extent of existing erosion problems or potential for future problems. Following the analysis, the team develops treatment prescriptions for each site, providing a blueprint of the proposed rehabilitation. Once prescriptions are made, environmental documents can be prepared, permit applications can be filed, and contract specifications can be developed.



Team members conduct geomorphic mapping and review prospective treatment sites.

Once the construction phase starts, the geologist serves as the project inspector and has three primary responsibilities. First, the inspector is responsible for outlining the proposed design to the heavy equipment operators and making on-site design modifications as the project proceeds. After conducting the field investigations, the inspector is very familiar with the site and can direct the equipment efficiently. The inspector guides the day-to-day heavy equipment operations and assists the operators in understanding the design specifications. Second, the inspector is responsible for protecting the natural, cultural and capital resources of the prop-



When working with heavy equipment, good communication between the inspector and the operators is a must! Communication improves job quality, prevents accidents, and encourages steady production.

erty owner, whether it be public or private land. The inspector will exercise the authority given to him/her by the property owner and permitting agencies to halt operations if equipment work poses a threat to any resources outside the work area. Third, the inspector keeps records of the project's progress. This includes equipment operating time, operator's time on the job, time spent on individual tasks such as brushing or recontouring, and other topics of interest. On some jobs, inspectors will keep track of equipment production for many different phases of the project to better analyze the overall job effectiveness. Inspectors may be tracking things such as the number of bucket loads of soil per hour moved, the time spent on positioning equipment, the relative efficiency of the dozer compared to an excavator when moving brush, or time spent placing and compacting fill material.

The inspector works closely with the equipment operator to maximize the quality and quantity of work accomplished. The inspector also analyzes the planning team's work to find ways to improve project planning and design. By recording the details of each project, the inspector strives to improve project quality and efficiency. Because watershed



In addition to keeping production data, the inspector coordinates equipment working together to remove a large crossing.

rehabilitation is a developing science, there is always opportunity for developing new techniques and more efficient ways to get the job done.

The inspector is also responsible for evaluating the results of the project. After the field season ends, the inspector will take a detailed look at the notes from the project. The inspector then writes a project report and discusses each step of the planning and construction phase. The inspector will explore ideas on how to improve future projects. When the rainy season arrives, the inspector and other team members will review previously rehabilitated roads to evaluate the performance of their prescriptions and the operator's workmanship.

ROLE OF THE EQUIPMENT OPERATOR

The most important role the equipment operator plays during the project is to determine the safest and most efficient use of equipment. Road removal jobs are often complex and difficult, and it is the operator's responsibility to decide the best way to maneuver and position equipment. This includes the order in which work is done and any intermediate steps that may be required to finish the job.

Experience has shown time and time again that the roles of inspector and operator should be clearly defined at the outset and maintained throughout the project. The inspector should, in most cases, refrain from telling equipment operators how to conduct the excavation. Instead, the inspector should remain focused on the design of the finished product. However, maintaining a frequent dialogue during excavations is important so that both the inspector and operator can understand how the work is proceeding.

Remote locations, steep terrain, and unstable embankments make most road removal sites extremely hazardous. Working as a team, it is important to take time to talk about safety. Steps should be taken to develop safe working conditions. The operator is ultimately responsible for safety related to operation of equipment and must take all precautions to avoid accidents. The operator should tell other workers about blind spots or limitations of the equipment in unstable locations. It may seem clichéd, but it's no joke – safety comes first and is everyone's responsibility!



Road removal work is as much art as a science. Operators share their vision with inspectors and then shape it into reality. Here a large log has been removed from a Humboldt crossing.

An operator's main job is to reconstruct the desired landscape to design specifications. Based on the specifications, the operator will develop the procedure for accomplishing the prescribed work. The key to maximizing production on a road removal job is to develop efficient material handling techniques. This is what makes some operators stand out as being the best. Good operators are always looking for ways to

improve their work. Try to figure out ways to combine two tasks into one, or eliminate work if you can think of a better way to get it done. Operators should consult with the inspector on strategies. The inspector may not be expert at operating equipment, but is watching the work proceed and has many useful suggestions.

The equipment operator should carefully monitor the number of hours worked on each project. The hour meter in the machine can be used and it should be double-checked using a watch. Each day the operator should discuss with the inspector the number of hours worked.

The operator and the inspector each keep a notebook to record time worked. Depending on the contract specifications, some projects pay by the operator time, some pay by equipment time, some pay by the volume of soil moved, and some pay by a total cost estimate. Equipment time contracts require the most careful record-keeping because time for breakdowns, fueling, and maintenance is



The operator's job is to determine the most efficient use of the equipment and how to best tackle any problem. The excavator feeds crossing fill into a slot the dozer has built to efficiently push the fill several hundred feet.



An operator consults the inspector to review the extent of the excavation. The excavation boundaries should be clear to the operators before digging begins. A few minutes discussing the site design can save hours of equipment time if a mistake is made.



Dozer and excavator work together to move an especially stubborn boulder.

not paid. In some cases, the number of hours of equipment time can be different from the number of hours the operator works each day. Be sure to talk to your supervisor to know if you get paid by the hour on the job, or by equipment operating time.

Last but not least, the operator should have good communication with the inspector. Good communication improves job quality, prevents accidents, and makes the workday more enjoyable. It also prevents payment disputes and ensures proper contract implementation.

SELECTING THE RIGHT EQUIPMENT FOR THE EXCAVATION

Equipment selection is a very important aspect of road removal work. It is important because the choice of equipment will have the most direct effect on the cost of the earthmoving tasks. It is best to consult with heavy equipment operators to determine the best combination of equipment. Three things are generally considered: type, size, and configuration.

On most projects an excavator and a bulldozer are both used together. The excavator primarily handles brush and retrieves fill from hard-to-reach locations. The dozer moves material along the road, shapes, and compacts. In some situations where roads are especially narrow and on very steep sideslopes, a dozer may not be usable. It may require two excavators to keep up with the dozer, when the dozer can be used at peak efficiency.

In general it is recommended to use the largest machine that will safely fit on a road or project site while not limiting maneuverability or impacting the area outside of the excavation boundaries. Limitations on the size of the machine depend primarily on the road width and the proximity to “save” trees or other valuable resources. Many roads being removed are narrow and located on steep slopes or have valuable trees close by. In this case, smaller equipment is sometimes specified.

How the equipment is configured is also important. For dozers pushing long distances, a U-blade or semi-U blade works best. For fine shaping work or road-to-trail conversions, a 6-way blade is most efficient. Sometimes a dozer needs to be equipped with rippers, and other times it needs a winch. Excavators are usually fitted with short booms and sticks to increase lifting power and allow for more reliable rotation when working on steep slopes. A thumb on the excavator bucket is crucial for picking up logs or moving boulders. All equipment should be fitted with rollover protection structure (ROPS), and brush guards before working in the woods.



The equipment operator works closely with project managers to determine the most efficient size and type of equipment for each project site. Generally it is best to use the largest piece of equipment that can maneuver safely through the site, but sometimes you just have to make due with what you have! (Courtesy RNP)

SITE PREPARATION

DEVELOPING ACCESS

Prior to equipment arriving on site a work plan should be developed. The plan should include items such as access points, the order of work by site, fueling points, servicing needs, etc. Typically, road removal work begins at the farthest point from the entry location of the project and proceeds back toward the access point. Operators need to be aware not to cut off access to other roads scheduled for treatment as they work into the project site. It is also important to know which roads the inspector thinks are most important for removal. Depending on access issues, the high priority roads may be treated first. This is especially important when projects are implemented late in the season and poor weather could postpone treatments until the following year.

Before road removal work can begin, access roads need to be opened to allow for fueling and servicing of equipment. Opening access to project sites can sometimes take a day or more of equipment work. Roads may be grown over with trees and brush or can be damaged by gullies or landslides. A service truck cannot always get to the equipment if the road is too steep or if driving the road each day will cause too much damage to the environment by creating dust or mud. In some cases, a small dozer, an ATV, or a mechanical



Equipment selection is important. Sizes of equipment can range from small, easily maneuverable machines to large earth moving monsters.



A dozer reconstructs a temporary stream crossing over a failed Humboldt crossing to provide access to other equipment and service vehicles.

wheelbarrow may be used to transport fuel to sites where the service truck is unable to drive.

Vegetation being cleared from the road can be used to make cuttings, or can be dug up and transplanted to a different location. On most projects, a rare plant survey is conducted prior to road removal operations and plants will be flagged for protection. Depending on the conditions, some rare plants will be transplanted and some will be completely avoided.

Also, be cautious of any large trees or shrubs that are marked for protection.

Road removal projects often include reconstructing roads through landslides. Reconstruction may be necessary to provide access to sites farther down the road. When reconstructing a road through a landslide, keep the width to the minimum that will allow equipment to pass safely. Extra caution is required when working in landslides because they may still be unstable. Excavating landslide material can undermine the slope and cause additional soil to slide down.

Temporary stream crossings are often constructed when opening up access roads. Many of the stream crossings in old roads have been washed out and need to be reconstructed. Extra care should be taken to limit any soil entering a stream. Plan your installation of stream crossings in a way that will limit the amount of time you are working around water. A temporary crossing can be constructed by placing a small culvert into the stream to convey low summer flows. Some regulatory agencies require washed rock to backfill temporary culverts. In dry streambeds, brush and small logs can be placed over the streambed to protect the bed from damage caused by metal-tracked equipment. Remember that any material used in constructing a temporary crossings must be removed later, so use the minimum fill necessary.

BRUSHING

Brushing refers to the removal of trees and brush that are growing on the embankment, cutbank, and roadbed. Brushing is done at the start of a job to provide access, remove organic material that might be growing in the fill, prepare a site for recontouring, and to make enough room for the equipment to maneuver. Because recontoured fill must be free of most organic material, brushing is necessary to prepare the road for treatment. All trees growing in embankment fill material are removed. This allows complete recovery of fill material. Trees left standing in fill material are unstable because much of the soil ballast has been removed from around the root mass. Without sufficient root strength the trees easily blow over. Failed trees destabilize the remaining fill and can cause further erosion.

The presence of trees and brush on a road does not necessarily mean the road is stable. Trees provide temporary stability and protection against erosion, but not long-term stability. Trees grow old and fall, die from disease, blow over in wind storms, and can be killed by fire. Removing vegetation and treating the site as prescribed by the project geologist provides a permanent solution. After road removal, site conditions allow for rapid recovery of vegetation. Elimination of compacted road surfaces, recovery of topsoil, and stable slopes are much better for long-term forest health.

Pushing trees over with the excavator is preferred by most because it allows better control of the falling tree. The dozer can be used for removing brush and smaller trees but is limited to the roadbed and must be followed by the excavator to clear it from the road edges. In some cases, hand crews are used to clear vegetation and buck up large logs, however if trees aren't fallen properly they can make a real mess for the excavator. Once down, trees and brush are piled above the cutbank or placed as a windrow below the embankment for later use when mulching. When piling brush above the cutbank, space the piles evenly along the road so that the excavator doesn't have to walk too far to retrieve and spread the mulch.



Excavator removing brush from the fill slope to expose material for recontouring. Brush and logs should be placed in an out-of-the-way location to be used later as mulch on the final surface. Brushing provides room for equipment to maneuver and keeps large organic material from being buried in the recontoured fill.

PREPARING THE ROAD SURFACE



Excavator removing brush from the cutbank to prepare it for placement of recontoured fill. Buried organic material can cause a slip plane and underground piping as it decomposes, leading to fill failure.

After removing trees and brush, organic material such as leaves, twigs, and duff should be removed from the inboard ditch, cutbank, and embankment. The material should be stockpiled out of the way for later use. Organic materials are removed because once rotted they provide small conduits that runoff will flow into. If enough small conduits exist behind or under recontoured fills, they can lead to saturation and failure. Another benefit of saving organic material is that it is rich with seeds and nutrients. It can

be used as mulch on the finished surface to promote rapid revegetation of work sites.

The next step in site preparation is ripping the inboard ditch and road surface using dozer mounted rippers or the excavator. Ripping the inboard ditch reduces ditch “memory” by decompacting the bottom of the ditch and mixing rocks along the bottom of the ditch with soil. Ripping the road surface is especially important when the road has an outslope pitch. Ripping breaks up the hard compacted surface that was caused by traffic on the old road surface allowing the recontoured fill to bond with subsurface furrows created by the rippers. Some sites that do not have significant compaction or are insloped may not need to be ripped. If the dozer does not have rippers the excavator can decompact the surface by breaking it up with the teeth of the bucket. It is usually sufficient to decompact to a depth of about one foot.



Trees left standing in unexcavated fill often fail because they lack sufficient soil ballast to hold them upright in high wind. All fill material should be removed regardless of the vegetation growing on them.

Where large inboard ditches or gullies have developed, operators should cut cross-drains from the ditch to the outboard edge of the road. The cross-drains should be cut to the depth equal or deeper than the ditch and should drop toward the outboard at a downslope angle across the road. The cross drains should only be placed where they can be drained into natural depressions. After the cross-drains are cut they are buried with recontoured fill to provide subsurface relief of ditch memory flow.



Following the removal of organics, the next step in site preparation is ripping the inside ditch and road surface to decompact the surface and increase permeability. Ripping breaks up the hardpan that was caused by compaction on the old road surface. Left, dozer begins to rip the inside ditch. Right, after numerous passes with the rippers, the inside ditch is thoroughly removed.